NA-65-1103

SERIAL NO. 62

PHASE II REPORT

TITANIUM S-IC SKIN SECTION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

GEORGE C. MARSHALL SPACE FLIGHT CENTER

CONTRACT NO. NAS8-20530

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DATE 28 December 1965
NO. OF PAGES 22

NORTH AMERICAN AVIATION, INC. / LOS ANGELES DIVISION
INTERNATIONAL AIRPORT · LOS ANGELES, CALIFORNIA 90009

FOREWORD

The plans and accomplishments described in this report were made in the Phase II time period of the development program, from 29 November to 24 December 1965. This effort constitutes part of the requirements of NASA/MSFC Contract No. NAS8-20530, "Titanium S-IC Skin Section."

ABSTRACT

3523\

This report describes the manufacturing plan for the fabrication of the full-scale integrally stiffened titanium skin section which is required as the end product of Phase III of the development program.

Also included are descriptions of the quality assurance (inpsection) plans and the test evaluation program.

Design drawings and photographs pertinent to the plans for the full-scale skin section also are presented in this report.

SUMMARY

The manufacturing plan for the fabrication of a full-scale titanium skin section to be delivered to NASA/MSFC, as required by the terms of Contract No. NAS8-20530, consists of the following principal tasks:

1. Fabricate detail component parts for two roll diffusion bonding packs, per NAA Drawing No. 2624-010.
2. Fit up and assemble two packs.
3. Weld, hot purge, and seal two packs.
4. Hot roll two packs to a 60-percent reduction.
5. Remove yoke by oxyacetylene torch cutting and cover plates by mechanical and/or chemical means.
6. Remove steel from body of pack by chemical leaching.
7. Remove 0.002 inch from all surfaces of titanium panel by shot grit blasting and the Chem-Mill Process.
8. Bisect one panel longitudinally.
9. Weld one half-panel to the remaining full panel to produce the full-scale skin section, per NAA Drawing No. 2624-202.

The quality assurance plan consists essentially of the following operations:

1. Dimensionally inspect all detail component parts.
2. Oversee and approve fit-up and assembly operations.
3. Inspect welded pack assemblies for possible leakage.
4. Oversee and approve hot purging operations.
5. Dimensionally inspect titanium panels.
6. Certify welding operation and inspect weld by X-ray and penetrant methods.

In the test evaluation program, the remaining half panel will be subjected to destructive and nondestructive tests in the NAA/LAD Production Development Laboratory and Engineering Structures Laboratory.

The tests will be of the same nature as those conducted on the Phase I subscale test panels. Specimens will be prepared and processed to determine tensile strength, bond adhesion, and microstructure.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

MANUFACTURING PLAN

The ultimate objective of the entire development program being conducted under Contract No. NAS8-20530 is the fabrication of a full-scale titanium S-IC skin section. NAA Drawing No. 2624-202, shown in figure 1, is the engineering design of the S-IC skin section to be manufactured during Phase III of the program.

During Phase I, six subscale test panels have been designed, fabricated, and tested. Based on the knowledge gained from Phase I experience, a manufacturing plan for the fabrication of the full-scale skin section has been prepared for approval by NASA/MSFC.

Sequential operations in the manufacturing plan are shown in figure 2, bar charted on a proposed progress schedule. Inspection effort is tied in with this plan, which is based on an anticipated go-ahead date of 3 January 1966.

MATERIAL

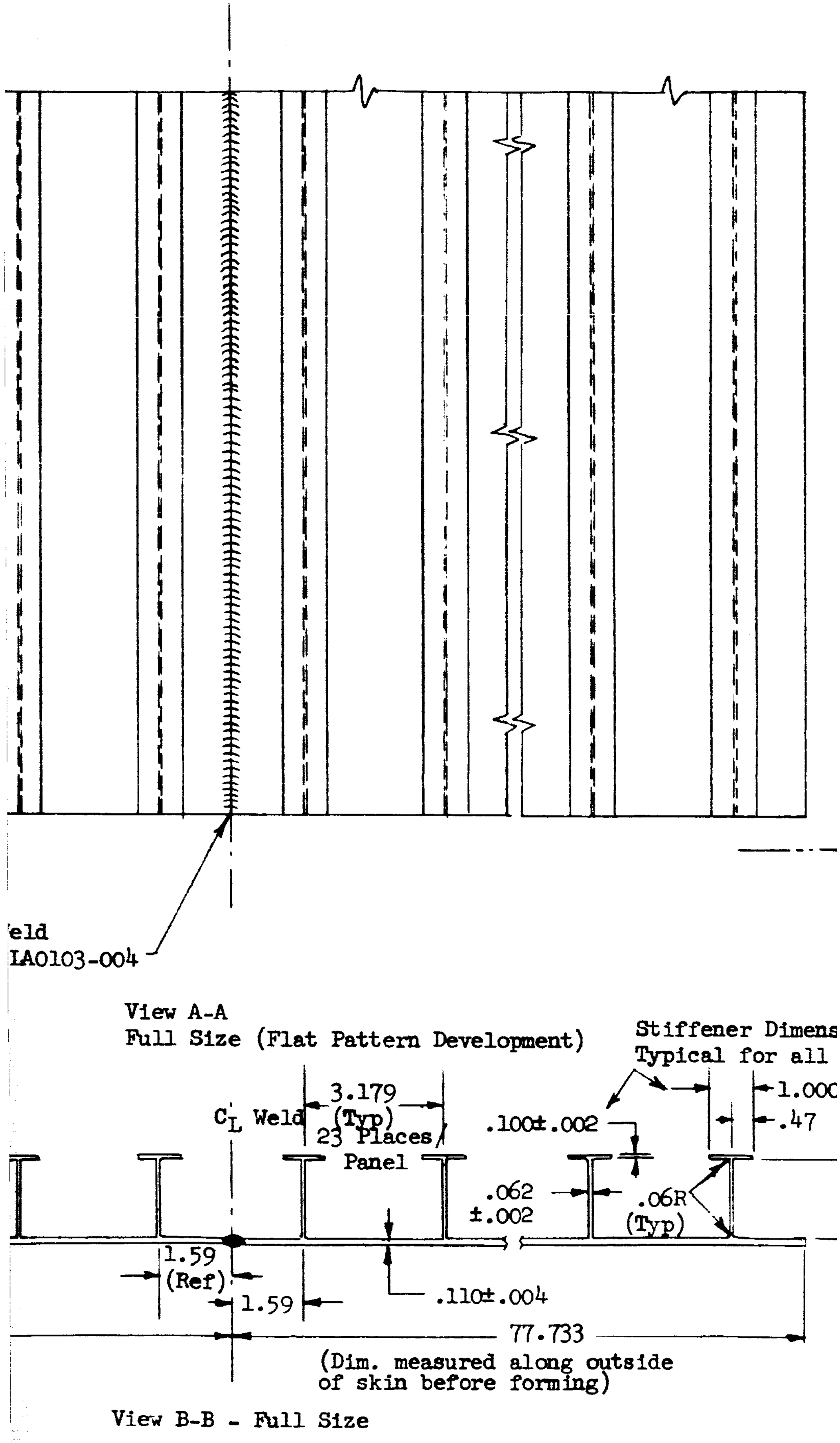
All of the material required for the Phase III packs was ordered during the Phase I time period, as authorized by the contract. Delivery of the 8Al-1Mo-1V titanium has been promised by 12 January 1966. Steel for the yokes, cover plates, and filler bars is scheduled for delivery beginning 10 January, with the last item promised for 28 January.

PRODUCTION PLANNING TICKETS

NAA Drawing No. 2624-010, "Pack Assy. - S-IC - 28 Ft. Panel Ph. III," shown in figure 3, is the basis for manufacturing effort to produce the two full-scale titanium roll diffusion bonded panels required in Phase III.

A production planning ticket will be issued for each detail, each subassembly, and the final assembly in accordance with figure 3. Each ticket will itemize the fabrication, processing, and inspection operations which must be performed to produce a quality product.

The ticket serves as a continuing record of progress as the detail part, or assembly, moves through the fabrication sequence. It also establishes the scheduled completion dates which the manufacturing departments are required to meet.



'eld
IA0103-004
View A-A
Full Size (Flat Pattern Development)
Stiffener Dimens
Typical for all
3.179
(Typ)
23 Places
Panel
C_L Weld
.100±.002
1.000
.47
.062
±.002
.06R
(Typ)
1.59
(Ref)
1.59
.110±.004
77.733
(Dim. measured along outside
of skin before forming)
View B-B - Full Size

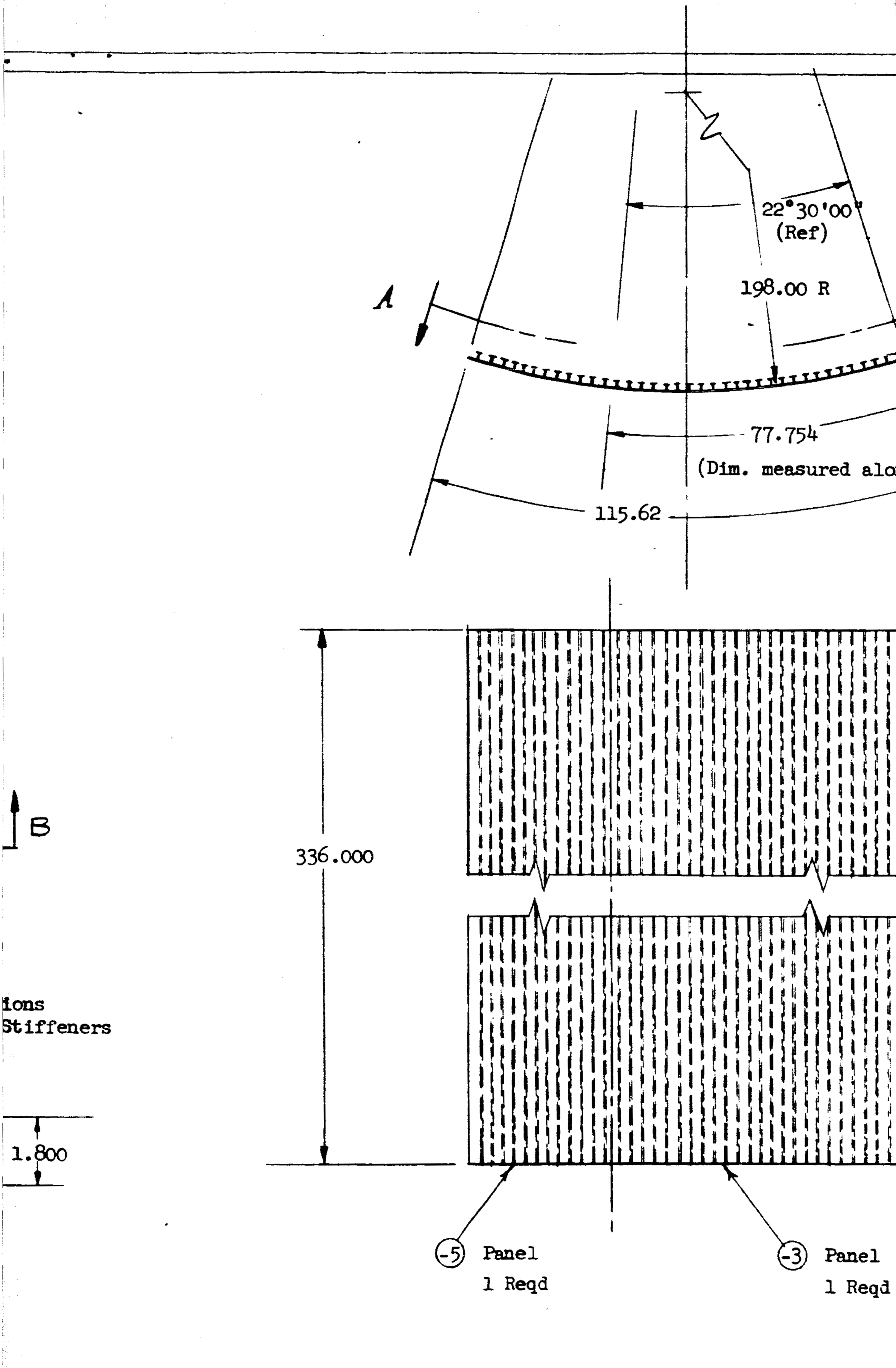


Figure 1. Full-scale Titanium S-IC

g outside of skin after forming to contour)

MATERIALS: -5 Make from 1/2 of -3 panel.

-3 Make all elements from 8Al-1V-1Mo titanium alloy Cond A LB0170-177

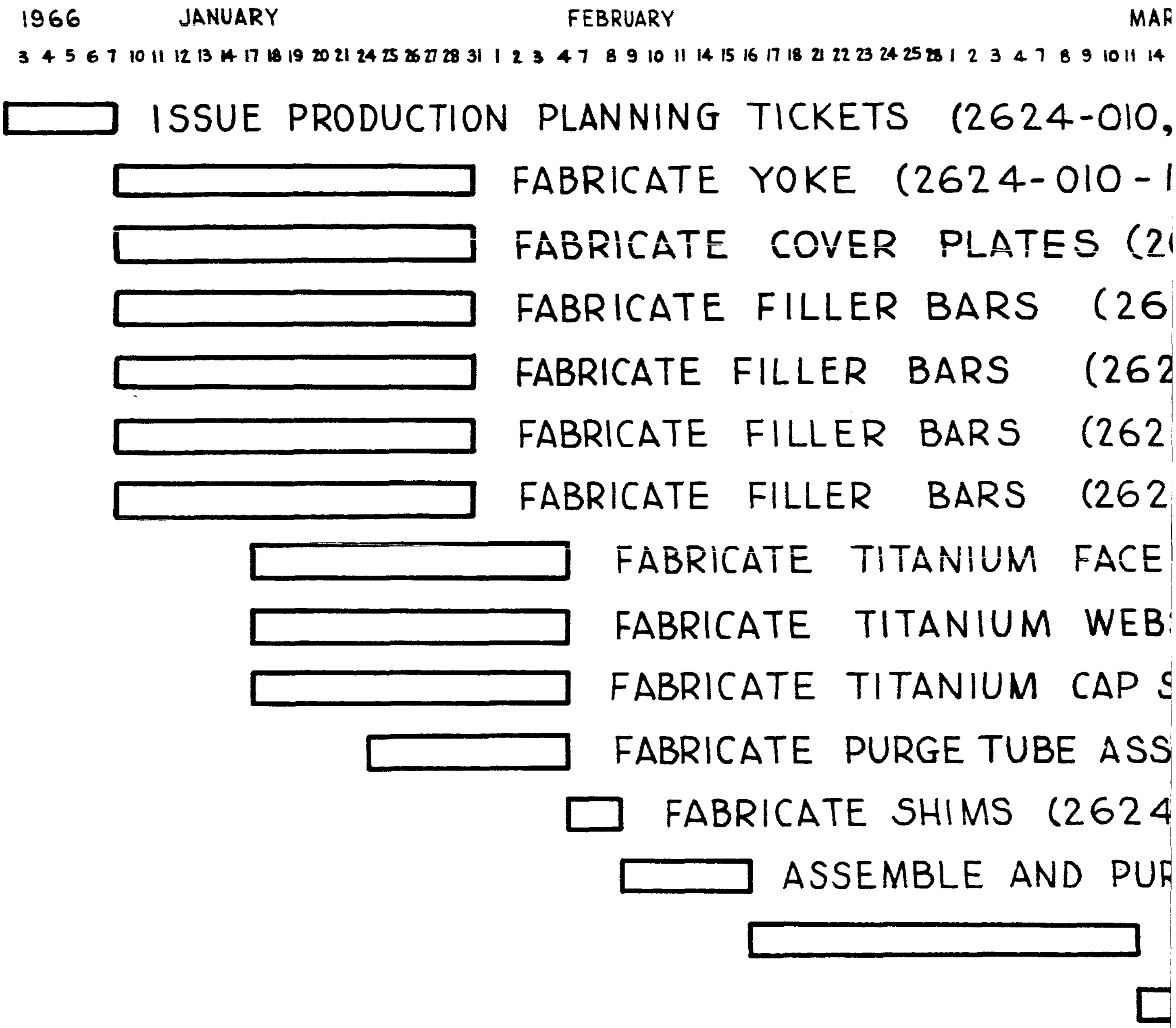
NOTES: (Unless otherwise noted)

7. Diffusion bond per specification.
6. Heat treat -3 and -5 panels to Cond "DA" before welding per Specification LA0111-028.
5. Chem-Mill per Specification LA0103-003.
4. Machine per Specification LA0103-004.
3. Standard detail per Specification LA0102-012.
2. Inspect per Specification MIL-I-6870 (LQ0501-007).
1. Dimensions are in inches.
   Tolerance on decimals - 2 place (.XX) = ±.03
   3 place (.XXX) = ±.010
   Angles ±30'

2624-202

Skin Section

MANUFACTURING PLAN FOR FULL SC
NAS 8



ALE TITANIUM S-IC SKIN SECTION
-20530

CH APRIL MAY

15 16 17 18 21 22 23 24 25 28 29 30 31 1 4 5 6 7 8 11 12 13 14 15 18 19 20 21 22 25 26 27 28 29 2 3 4 5 6 9 10 11 12 13 16 17 18 19 20

2 REQ'D)

01, 1 REQ'D PER PACK)

524-010 -118, -119, 1 EACH REQ'D PER PACK)

24-010 - 113, 2 REQ'D PER PACK)

4-010 - 114, 23 REQ'D PER PACK)

4-010 - 120, 2 REQ'D PER PACK)

4-010 -122, 23 REQ'D PER PACK)

SHEET (2624-010-116, 1 REQ'D PER PACK)

S (2624-010 -115, 24 REQ'D PER PACK)

TRIPS (2624-010-121, 24 REQ'D PER PACK)

Y (2624-010-108, -109, -110, -111, 1 REQ'D PER PACK)

-010-106,-112, 1 EACH REQ'D PER PACK)

GE PACKS (2624-010 2 REQ'D)

SHIP, ROLL, AND RETURN PACKS

OPEN PACKS

MACHINE EDGES FOR WELDING

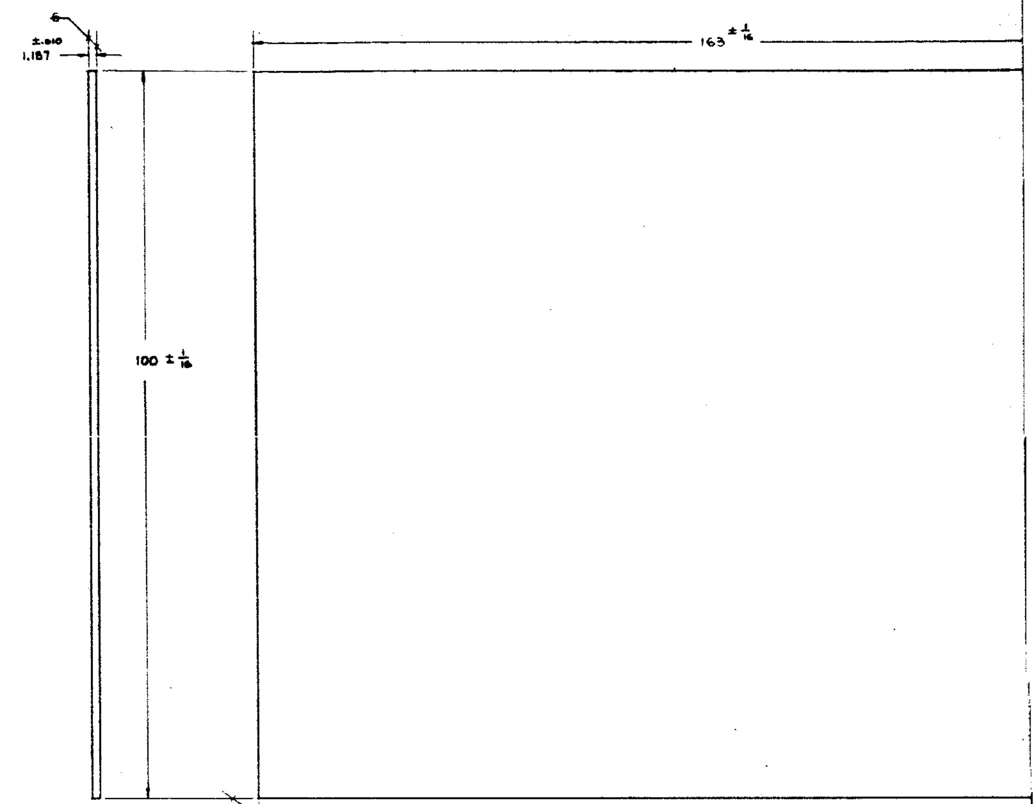
REMOVE FILLER BARS

CHEM-MILL PANELS TO FINISH DIMS.

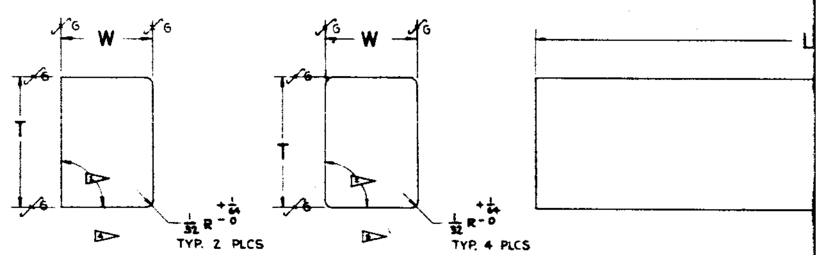
WELD FINAL ASSY

SHIP TO NASA/MSFC

Figure 2. Manufacturing Plan



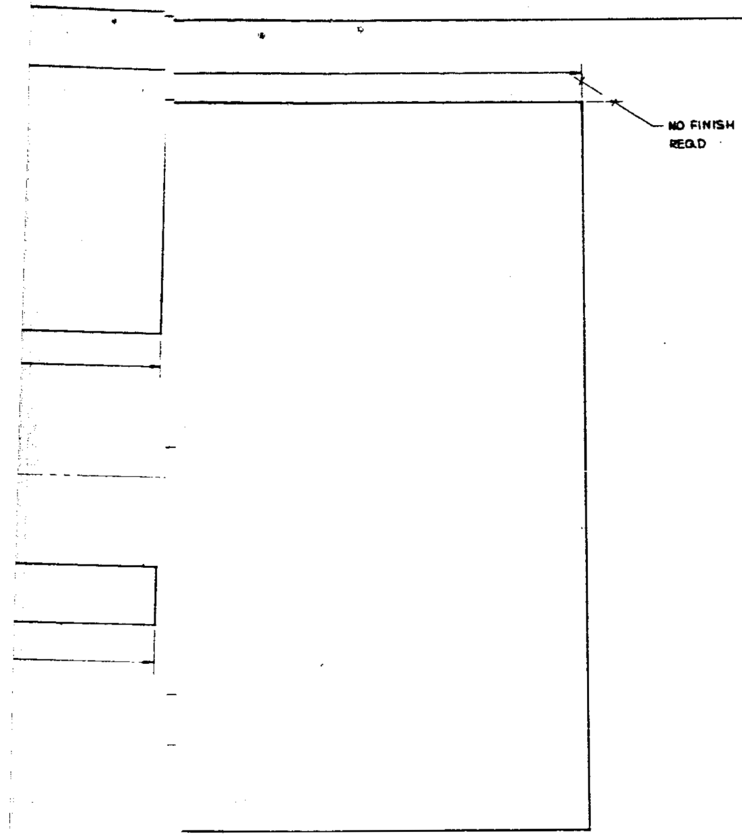
(119)(118) A7 HRS COVER PLATE — NO FINISH REQD
1 1/2 x 100 x 163 1 REQD
17



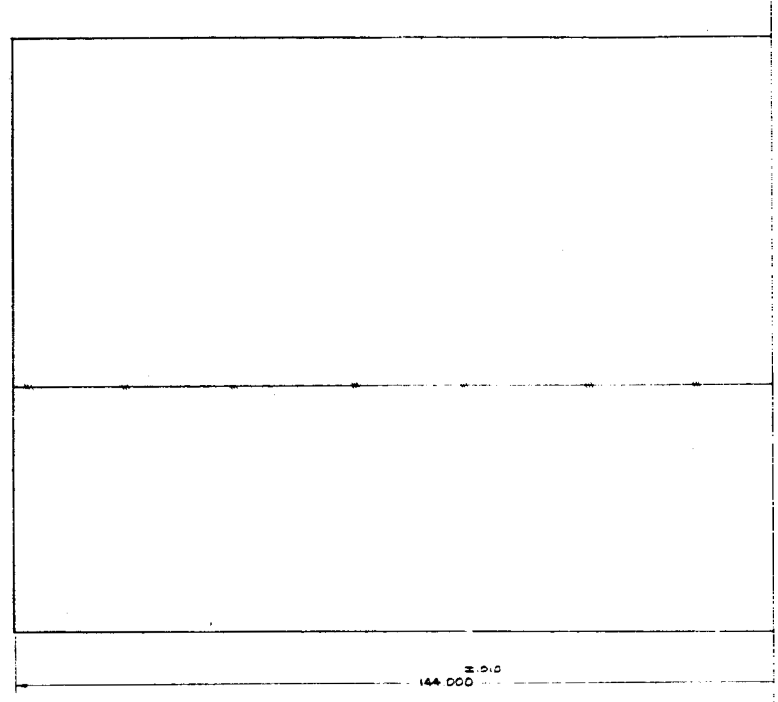
DET. NO.	T ±.002	W ±.002	L ±.010
122	.260	2.235	144.000
120	.260	2.704	↕
114	4.490	3.173	↕
113	4.490	3.173	144.000

C-1018 OR C-1020 COLD FINISH STL.
SEE SECTION **A A** 16

NOTE –
1. ALL CORNERS MUST BE 90° ± 0°5'

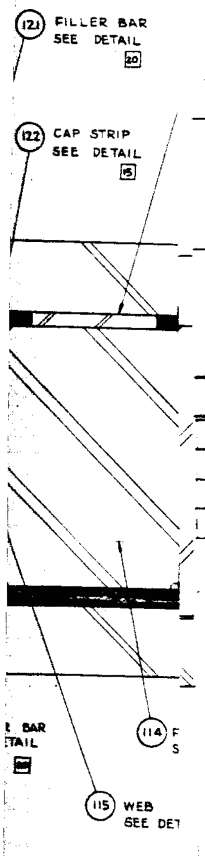


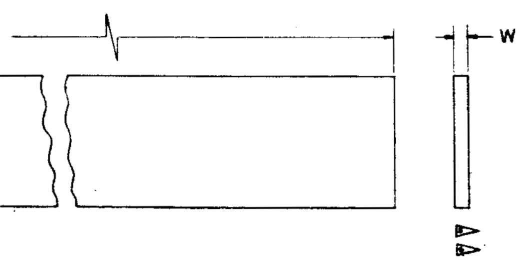
2624-010
SCALE – 1/8



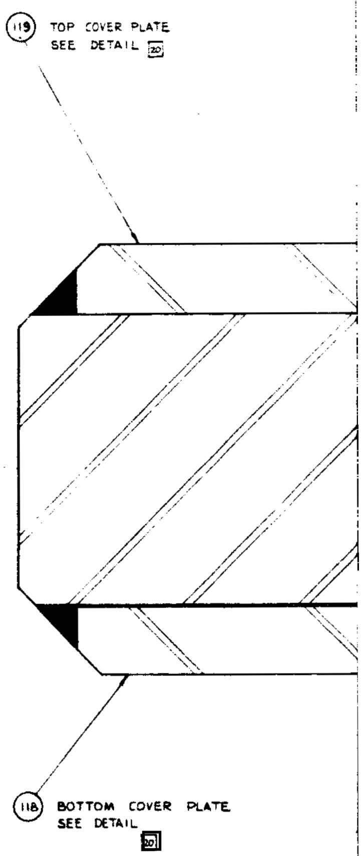
(116) 8-1-1 TITANIUM ALLOY (DUPLEX ANNEALED) FACE SHEET
.285 x 43 x 144 2 REQD

NOTE! WELD PER SPEC LA0111-028

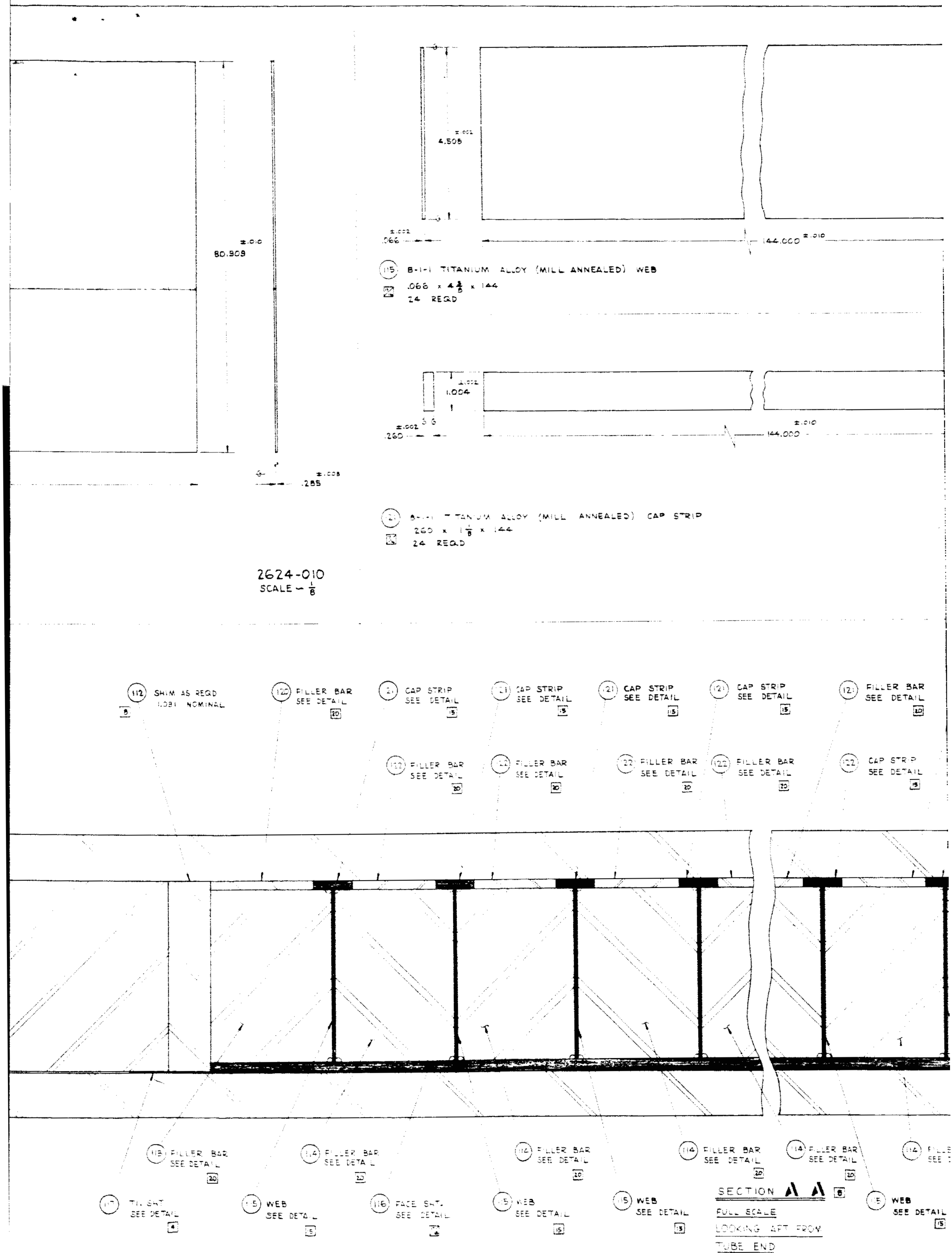




NO. REQ'D
23
2
23
2

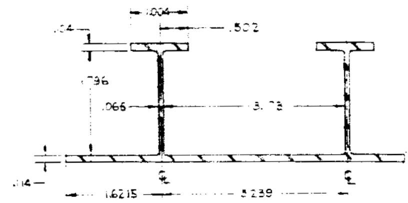


2624-010
SCALE – NONE


80.909 ±.010
.285 ±.008
4.508 ±.002
.066 ±.002
144.000 ±.010
(115) B-1-1 TITANIUM ALLOY (MILL ANNEALED) WEB
.066 x 4 1/2 x 144
24 REQD
1.004 ±.002
.260 ±.002
144.000 ±.010
(121) B-1-1 TITANIUM ALLOY (MILL ANNEALED) CAP STRIP
.260 x 1 1/8 x 144
24 REQD
2624-010
SCALE — 1/8
(112) SHIM AS REQD 1.031 NOMINAL
(122) FILLER BAR SEE DETAIL 20
(121) CAP STRIP SEE DETAIL 15
(121) CAP STRIP SEE DETAIL 15
(121) CAP STRIP SEE DETAIL 15
(121) CAP STRIP SEE DETAIL 15
(121) FILLER BAR SEE DETAIL 20
(122) FILLER BAR SEE DETAIL 20
(122) FILLER BAR SEE DETAIL 20
(122) FILLER BAR SEE DETAIL 20
(122) FILLER BAR SEE DETAIL 20
(122) CAP STRIP SEE DETAIL 15
(113) FILLER BAR SEE DETAIL 20
(114) FILLER BAR SEE DETAIL 20
(114) FILLER BAR SEE DETAIL 20
(114) FILLER BAR SEE DETAIL 20
(114) FILLER BAR SEE DETAIL 20
(117) TI. SHT. SEE DETAIL 4
(115) WEB SEE DETAIL 15
(116) FACE SHT. SEE DETAIL 4
(115) WEB SEE DETAIL 15
(115) WEB SEE DETAIL 15
SECTION A A 8
FULL SCALE
LOOKING AFT FROM
TUBE END
(115) WEB SEE DETAIL 15

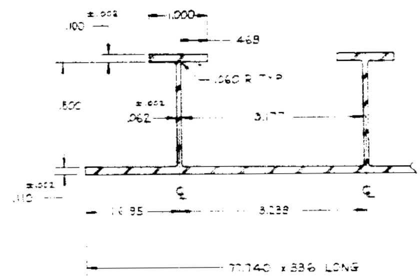
16

15



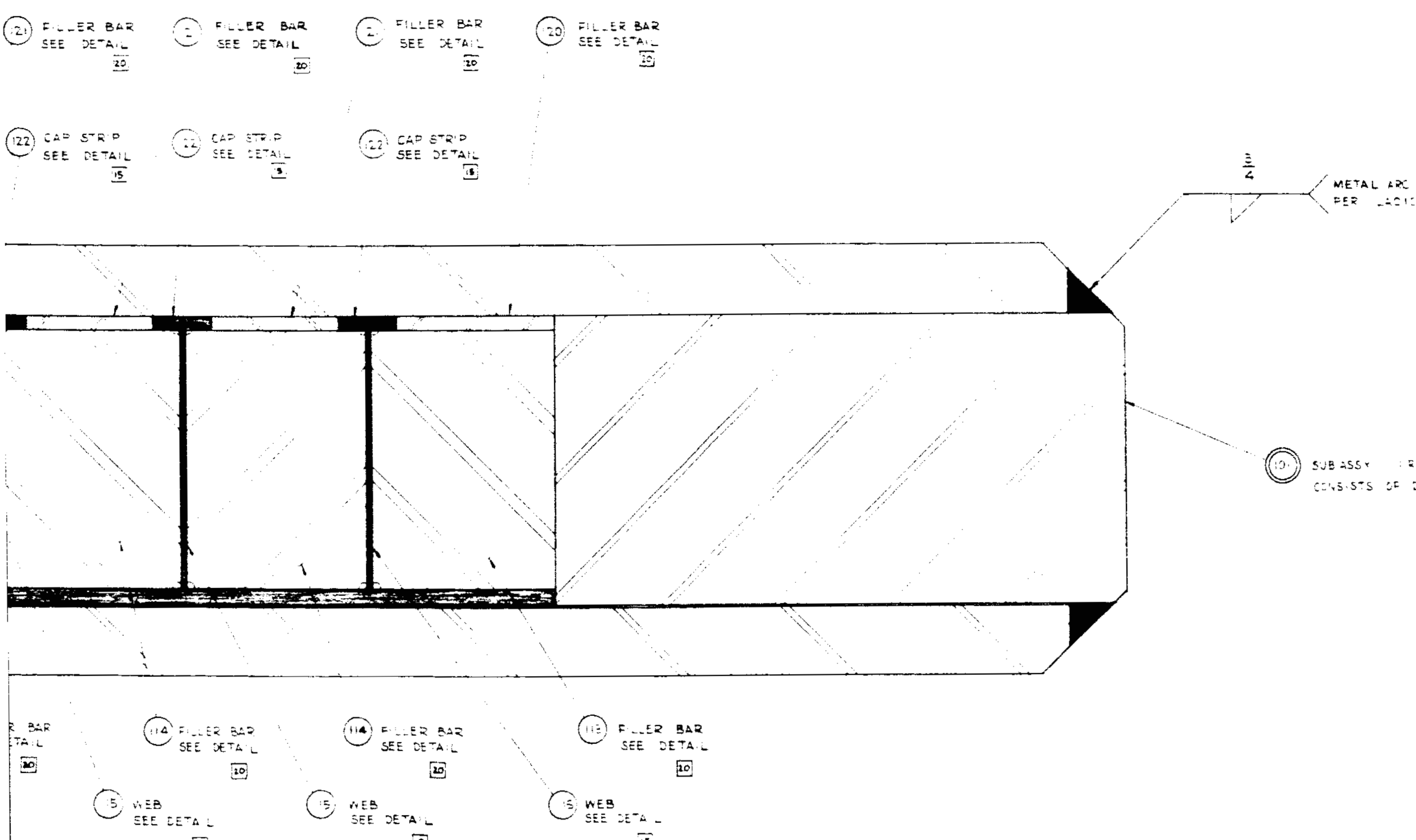
PANEL AFTER ROLLING
& BEFORE CHEM MILLING

2624-010
FULL SCALE



2624-010
FULL SCALE

PANEL AFTER CHEM MILLING

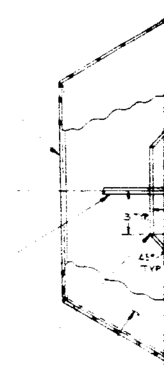


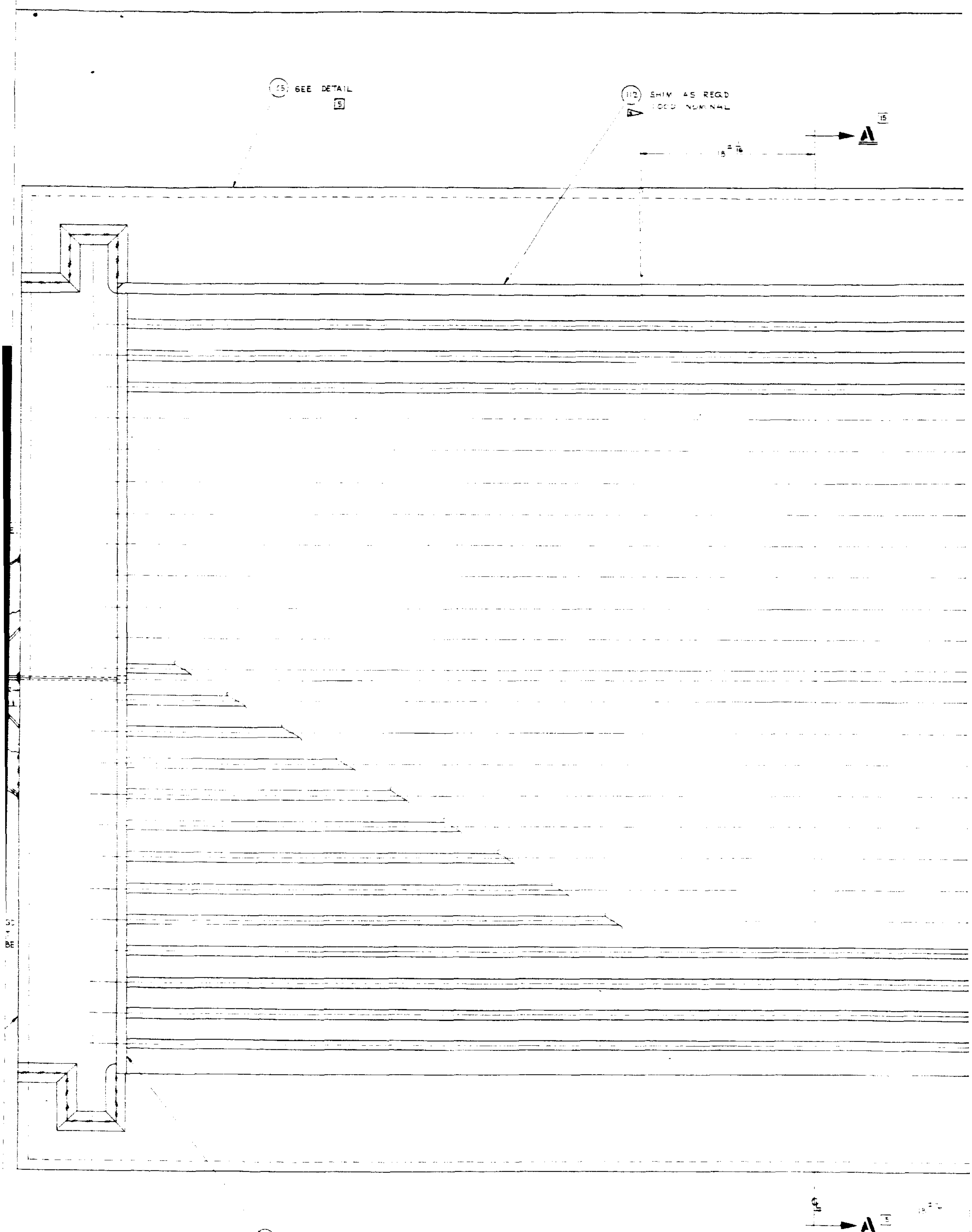
2624-010
FULL SCALE

2624-010
FULL SCALE

ELD
-004

RD [5]
TAILS



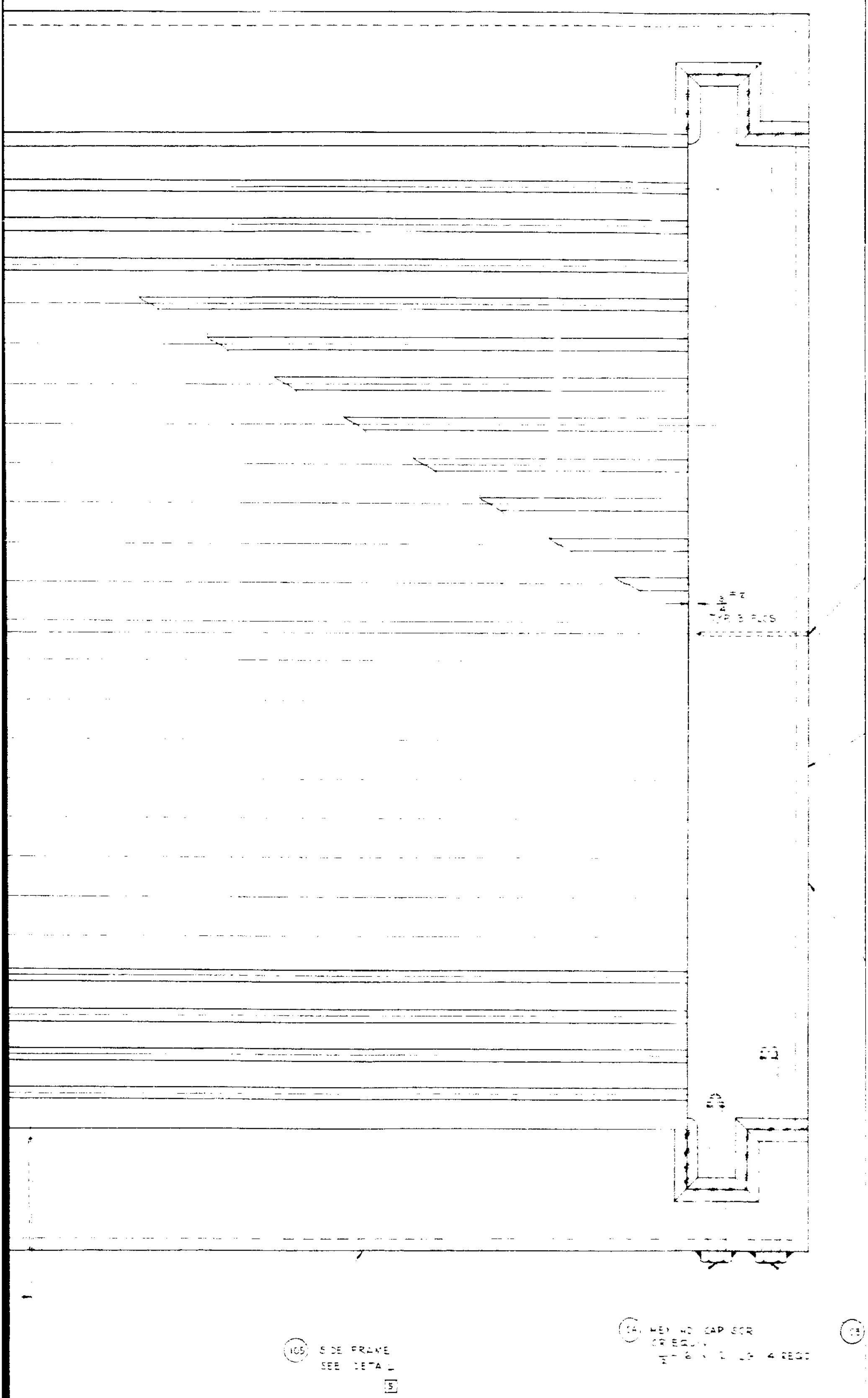


PLAN VIEW DET. -119 TOP COVER PLATE OMITTED FOR CLARITY – $\frac{1}{4}$ SCALE –

9

4-6

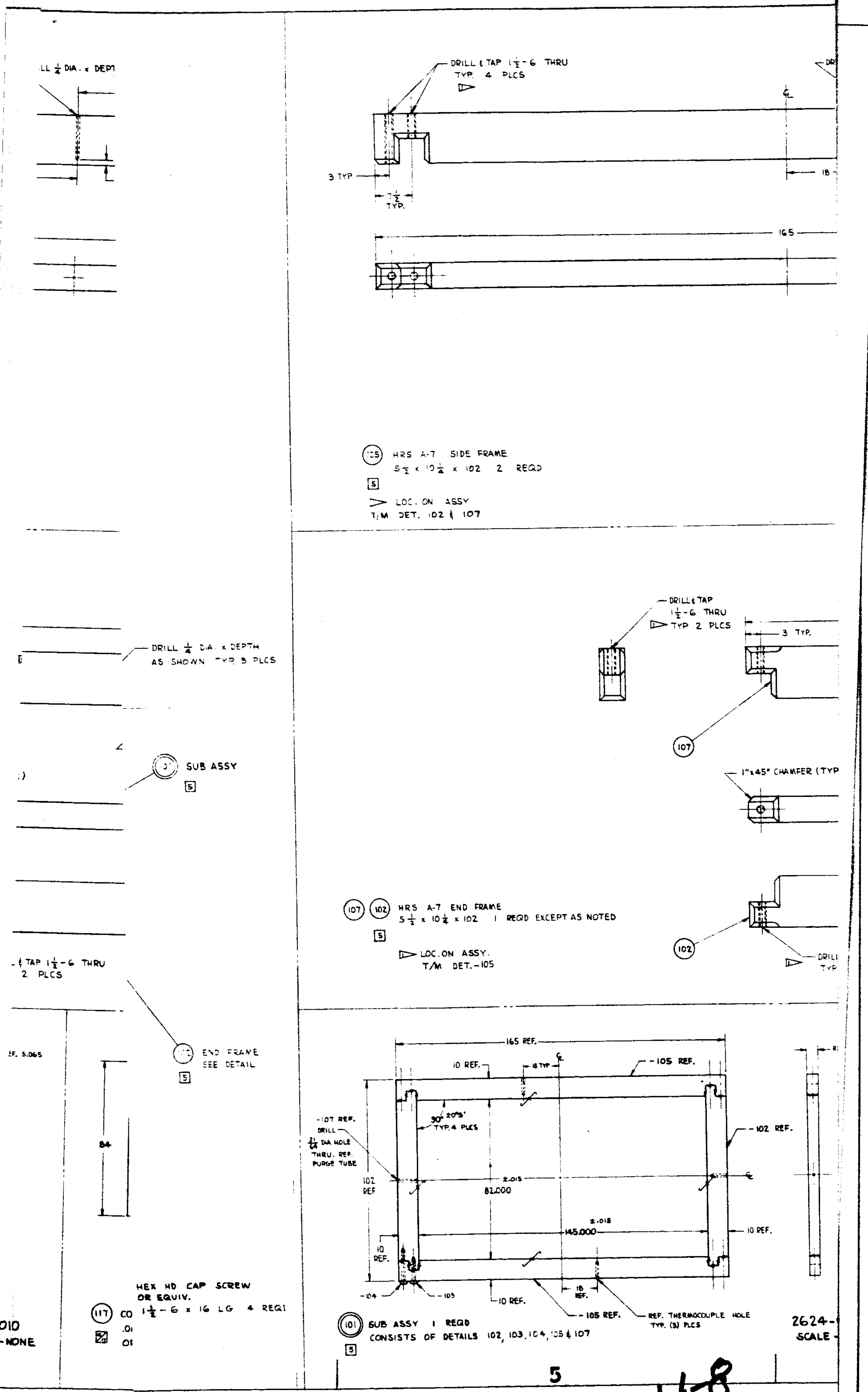
8



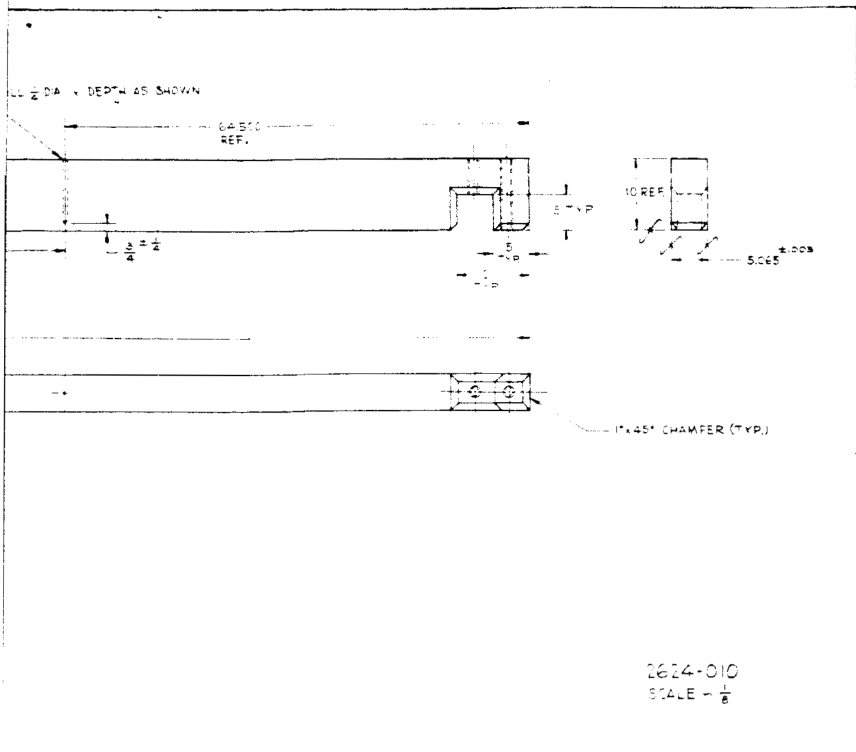
TYP 3 PLCS
105 SIDE FRAME
SEE DETAIL
5
HEX HD CAP SCR
OR EQUIV
4 REQD

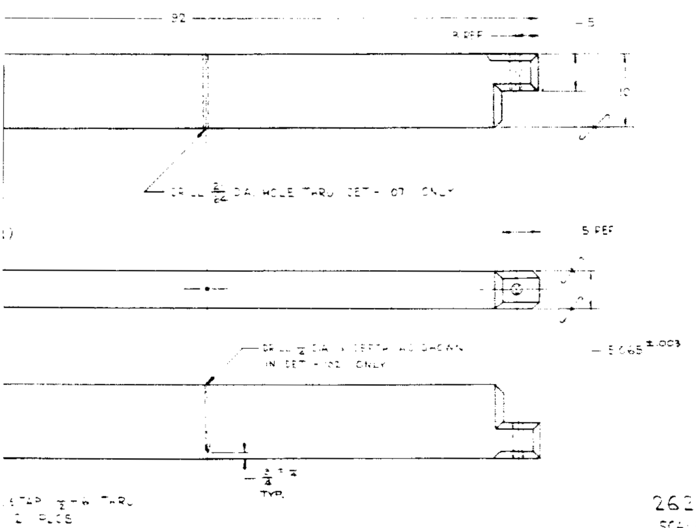
7

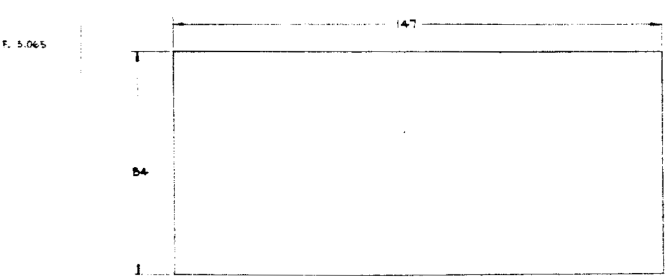
6



LL 1/4 DIA. x DEPT
DRILL & TAP 1 1/2 - 6 THRU
TYP. 4 PLCS
3 TYP
7 1/2 TYP.
18
165
(105) HRS A-7 SIDE FRAME
5 1/2 x 10 1/4 x 102 2 REQD
5
LOC. ON ASSY
T/M DET. 102 & 107
DRILL & TAP
1 1/2 - 6 THRU
TYP 2 PLCS
3 TYP.
107
1"x45° CHAMFER (TYP
DRILL 1/4 DIA. x DEPTH
AS SHOWN TYP 3 PLCS
SUB ASSY
5
(107) (102) HRS A-7 END FRAME
5 1/2 x 10 1/4 x 102 1 REQD EXCEPT AS NOTED
5
LOC. ON ASSY.
T/M DET. -105
102
& TAP 1 1/2 - 6 THRU
2 PLCS
END FRAME
SEE DETAIL
5
84
165 REF.
10 REF.
18 TYP
-105 REF.
-107 REF.
DRILL
21/64 DIA HOLE
THRU. REF.
PURGE TUBE
30° ±0°5'
TYP. 4 PLCS
-102 REF.
102 REF
±.015
82.000
±.015
145.000
10 REF.
10 REF.
-104
-103
10 REF.
18 REF.
-105 REF.
REF. THERMOCOUPLE HOLE
TYP. (3) PLCS
HEX HD CAP SCREW
OR EQUIV.
(117) 1 1/2 - 6 x 16 LG 4 REQ
(101) SUB ASSY 1 REQD
CONSISTS OF DETAILS 102, 103, 104, 105 & 107
5
010
-NONE
2624-
SCALE
5







010
NONE

(17) COM. PURE Ti. FOIL
.004 x 84 x 47 1 REQ'D
OPTION - FABRICATE OR SPLICE AS REQ'D

2624-010
SCALE - NONE

4 3 4-9

Figure

REVISIONS				
LTR	ZONE	DESCRIPTION	APP.	DATE

GENERAL NOTES!

1. MATERIAL OF PART – 8-1-1 TITANIUM ALLOY
2. WELD PER STD. SHOP PRACTICE, EXCEPT AS NOTED
3. DET –106 & –117 AS REQ'D AT TIME OF LAYUP. DRILL $\frac{3}{4}$ DIA. HOLE IN –106 SHIM & LOC. ON ASSY.
4. FRACTIONAL TOL. $\pm\frac{1}{32}$, EXCEPT AS NOTED. DECIMAL TOL. $\pm$.010, EXCEPT AS NOTED.

SCALE FULL & NOTED	DR N. MORIWAKI DATE 12-17-1965	NORTH AMERICAN AVIATION, INC. INTERNATIONAL AIRPORT LOS ANGELES 45 CALIFORNIA
PACK ASSY- S-IC - 28 FT PANEL PH. III ROLL DIFFUSION BONDING NAS 8-20530		2624-010

2

3 Pack Assembly for 28-foot Panel

FABRICATION OF THE YOKE

In Phase I, the six test packs were of a size which permitted the fabrication of each yoke from a single block of hot rolled steel. However, the Phase III packs will be so large that a one-piece integrally machined yoke is not considered practical within the limited scope of a development program.

It has been suggested by U.S. Steel Corporation personnel that individual steel plates, flame cut to the rough shape of the yoke, could be supplied for future large packs. This suggestion is being studied to determine comparative material costs, manufacturing costs, shipping charges, and fabrication and handling problems.

As shown in figure 3, the yoke for each Phase III pack will be a subassembly, identified as -101, consisting of individual machined details fitted, bolted, and welded together. The design of the corner joints is the result of studies conducted during Phase I to determine a type of construction which would be least disadvantageous to the rolling operation.

FABRICATION OF FILLER BARS

Evaluation of the first four titanium panel sections in Phase I indicated that the surface cracks were attributable in part to contamination from the steel filler bars. The latter had not been machined, but were used as received with, of course, a cleaning process prior to pack layup.

In the fifth and sixth packs of Phase I the steel filler bars were machined to dimension, solvent cleaned, and wrapped in protective paper, as shown in figures 4 and 5. This same procedure will be followed in the fabrication of the steel filler bars for Phase III packs.

FABRICATION OF TITANIUM DETAILS

The titanium material has been ordered to the required thickness and surface condition for layup so that machining in-house will be limited to width and length dimensions. It will be necessary to splice weld the face sheets to obtain the required width of 80.909 inches, since availability of material from the titanium suppliers is limited to a 48-inch width. Welding will be accomplished by the TIG fusion process, as has been done on the Titanium Cross Beam program.

All titanium components will be processed per established NAA practice, will be protected until assembly, and will be cleaned immediately prior to layup.

Figure 4. Protection of Machined Filler Bars

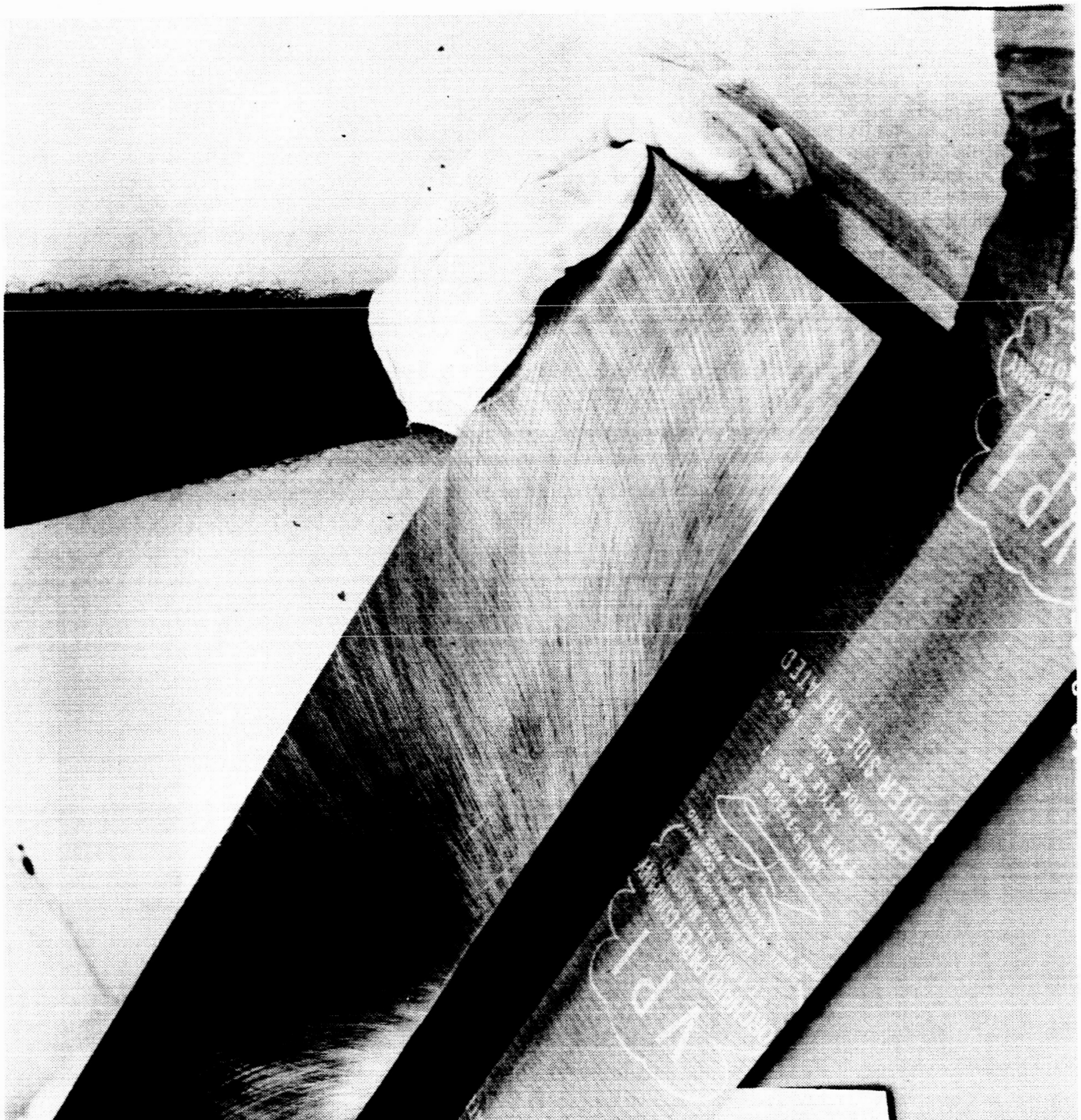


Figure 5. Unwrapped Steel Filler Bar

ASSEMBLY OF PACKS

Assembly of the packs will follow the same procedure that was used in Phase I for the test packs, with variations in handling due to size and weight of the full-scale components.

The clean room in Building 92, which has been the scene for all pack layup work to date, is equipped with a 6,000-pound overhead hoist, which is adequate to lift and lower any one detail part in the assembly. It is proposed that the steel filler bars be handled by power magnets, with adequate cleaning before and after handling to eliminate contamination.

It is planned that the yoke for each pack will be placed on a special carriage made up of heavy-duty die dollies joined by structural steel beams. Handling of the yokes and of the completed packs will of necessity be done by hired equipment, which is common practice at NAA.

To minimize handling and transportation, all welding required for pack assembly will be done in Building 92, as well as hot purging.

SHIPPING THE PACKS

Because of their size and weight, the packs will be shipped to the steel mill for rolling in an open gondola railroad car. It is estimated that one-way in a through car to Gary, Indiana, or Sparrows Point, Maryland, requires from 10 to 14 days.

The railroad siding in NAA's shipping area is approximately 200 yards from Building 92. Transporting the packs from Building 92 and loading into the freight car will be done by hired rig.

It is planned that, after rolling, the packs will be flame cut at the steel mill to reduce size and weight to a minimum. If time and cost warrant it, the trimmed packs might be returned to NAA by truck.

MACHINING EDGES FOR WELDING

Before the steel filler bars have been removed, while the body of each pack is still essentially a solid plate, it is planned that one pack will be machined longitudinally into halves, and that the edges of one half-pack and the remaining whole pack which will constitute the weld joint in the subsequent assembly will be machined. The machining will be done in Department 62.

The machining operation is predicated on the assumption that the outline of the titanium panel in the pack will be sufficiently distinct to establish trim lines. If this should not be the case, then an alternate procedure will be followed in which machining will be accomplished after removal of the steel filler bars.

REMOVING THE FILLER BARS

During Phase I, several methods for separating the titanium panel from the steel filler bars were tried. Thermal shock, both cold-to-hot and hot-to-cold, was not successful and, in fact, was damaging to the titanium.

Physical separation by means of pressure on the pack between form blocks resulted only in partial separation, not enough to permit removal of the filler bars.

Another method which was not successful was the vibration of the pack in a bath of penetrating oil, the thought being that the fluid would seep between the titanium and steel to permit the bars to be pushed out of the pack from one end.

Successful removal of the steel bars was accomplished by leaching. Packs were immersed in Chem-Mill Process tanks until the steel was completely dissolved, leaving the titanium panels unaffected.

Chemical leaching is planned as the method for removing the steel from the Phase III packs. It should be pointed out that, while there are existing facilities to accommodate the large packs, there are factors which might influence a change in plans.

The fumes from leaching might be in violation of county air pollution control regulations. The cost of installing equipment to control fume emission might be prohibitive in terms of this program's limited budget.

The complete loss of the steel could make leaching an impractical method in terms of future production quantities of roll diffusion bonded titanium structures. Since one of the principal goals of the development program is to determine fabrication methods which could be adapted to production use, further investigation of ways to remove filler bars seems warranted.

CHEM-MILLING TITANIUM PANELS TO FINISH DIMENSIONS

Laboratory analysis of test packs showed that minor surface cracks in the titanium were caused in part by an iron-titanium embrittling contamination.

It is planned that shot grit blasting and the Chem-Mill Process will be used in Phase III to remove 0.002 inch from all surfaces of the titanium panels after removal of the steel filler bars. An allowance for this final dimensioning operation has been calculated into the design of the pack assemblies.

WELDING THE FINAL ASSEMBLY

Based on NAA's accumulated experience in welding titanium, the final assembly of the full-scale S-IC skin section, as shown in figure 1, will be accomplished by welding per the requirements of NAA Process Specification LA0111-028.

Welding will be performed in Department 017 on one of the existing machines. It is planned to use the Sciaky Boom Welder, which can accommodate the 28-foot panel and for which no special designed tooling will be required.

SHIPPING THE SKIN SECTION TO NASA/MSFC

The Packaging Engineering Department will design a special shipping container so that the full-scale skin section will be transported to Huntsville, Alabama, secured and protected in a draped position conforming to the 198.00-inch radius required by Drawing No. 2624-202. Shipment is planned by motor truck.

TOOLING CONCEPT

It is established policy at NAA that, on contracts of a prototype or developmental nature, special designed tooling be kept to an absolute minimum. This policy has been applied to NAS8-20530.

Throughout Phase I, fabrication methods were evaluated for their adaptability to the manufacture of the full-scale packs. As a consequence, the manufacturing plan proposed for Phase III has been devised so that no special tooling will be required.

Standard shop equipment will be used throughout Phase III for manufacture and inspection of details and assemblies. As in other NAA programs, it may be necessary to improvise shop aids, but such items are not classified as tools.

QUALITY ASSURANCE PLAN

The fabrication of details for the six Phase I test packs was performed by Department 214, Assembly Tooling. Accordingly, the parts were controlled by the same high standards of quality assurance which are used to inspect NAA tooling. This inspection plan proved to be very effective during Phase I and will be maintained through Phase III.

A Tooling Inspection Record form is used on which an itemized inspection record of each individual detail part is maintained. A second inspection log is provided by the production planning tickets which accompany all details and assemblies throughout the fabrication sequence.

In the case of the titanium components, additional traceability is assured by the recording of the heat numbers established by the supplier.

During layup and assembly of the packs in Department 017, Welding and Brazing, an inspector is assigned to maintain quality assurance surveillance. Again, the production planning tickets provide a written record of inspection as the pack fabrication progresses.

Quality control of welding operations is assured by the requirement that welding be performed per the appropriate NAA specification. Titanium welding is controlled by NAA Process Specification LA0111-028. Metal arc welding of the cover plates to the yoke is controlled by LA0107-004.

At the rolling mill, records will be kept of pack temperature during heat-up and soak, of the pressures and gap settings during rolling, and of pack temperature during cool-down.

After the titanium panels have been completely freed from the packs, they will be finish sized by the Chem-Mill Process per specification LA0103-003. Other specifications which will control panel fabrication are LA0103-004 for machining, LA0111-028 for welding, and MIL-I-6870 (LQ0501-007) for inspection.

The entire fabrication sequence throughout Phase III will, of course, be governed by the new NAA process specification, not yet assigned a number, entitled "Roll Diffusion Bonding of Titanium Alloys." A copy of this specification was included as Appendix A in NAA Report NA-65-1004, which in turn constitutes Appendix A of NAA Report NA-65-1043, "Phase I Report, Titanium S-IC Skin Section."

TEST EVALUATION PROGRAM

ENGINEERING TECHNICAL PLAN

A plan has been formulated for Phase III of the S-IC skin section program so that Structures R&E group will coordinate and monitor those activities deemed of technical nature. It is judged that best results can be achieved in this manner by one-source coordination of functions identified as technical as follows:

1. Engineering support of full-scale panel fabrication
2. Material data propagation
3. Assessment of quality control findings
4. Disposition of quality control non-spec items
5. Specimen structural test and data reduction
6. Package design of final panel shipment pack
7. Technical Report

A necessarily incomplete list is included to describe some important details of the various task efforts for information and orientation of technical effort to the total program.

1. Engineering support for Phase III and IV. Technical effort with the selection of the final candidate already completed, technical problems incurred by variation of parameters in the full scale pack, such as gage and dimensional tolerances, processing of panel relating to removal of filler material, formulation of sub-element and element specimen test plan, etc, are a part of this support function.

2. Material data propagation relates to the compilation, sorting of mechanical properties of parent material, effective comparison to diffusion bonded zone properties for both discrete and repeated load cases. Weld joining allowables and fatigue data will be studied and compiled to the degree deemed necessary. Combined stress phenomena will be considered also.

3. Assessment of Quality Control determinations will be evaluated for effect on strength integrity and reliability. This is designated as review of findings action within North American Aviation. It involves

the structural assessment and interpretation of findings from non-destructive tests, coupon tests, surface finish, microphotos, etc, by Quality Assurance Group as they might relate to structural importance in the fabricated production parts. In general, the items listed conform to the accepted specifications.

4. Disposition of Quality Control non-spec items refers to items that are ticketed for what is known at NAA/LAD as MRD action. Here, each squawked item is referred for disposition to the structures technologist. In this category would be excessive tolerance variations in gages and dimensions, gaps, flatness of elements, scratches, nicks, cracks, local damage, etc. Metallurgical findings in the form of voids, inclusions, porosities, delaminations, imperfections in the material are included here. Often repairs are prescribed for the salvage and use of the parts whose integrity is established by analytical treatment.

5. Specimen structural test and data reduction encompasses the structural testing phase of the activity. Sizes ranging from 6 by 6 to approximately 12 by 40 inches will be selected from the one half panel portion of the T-stiffened wall remaining at NAA/LAD. Local and general stability tests will be programmed to acquire a number of points for the drawing of a buckling curve for the section over a range of slenderness ratios including, of course, appropriate assessment of end fixities. It is planned to tension test in the transverse-to-rolling direction sections that include the line of bonding, this being the direction of the hoop tension load incurred by internal pressure in the tank wall. Reduction of test instrumentation recordings to interpretable data will be performed in this task.

6. Packaging design for full-scale panel shipment will be studied to ensure safe transport of the two packs to the mill and back. Weight of each un-rolled pack adds up to approximately 37,000 lbs. The safe transporting of the final production panel to NASA/MSFC will require a special package.

7. A final report will incorporate all of the data, information and both positive and negative results compiled during the execution of the various tasks defined above.

Conclusions and recommendations will be added as a final input.

PRODUCTION DEVELOPMENT LABORATORY TESTS

The trim ends from both panels will be tested for tensile strength, bond adhesion, chemistry, and microstructure. Photographs such as shown in figure 6 will be taken to illustrate microstructure in the bond areas.

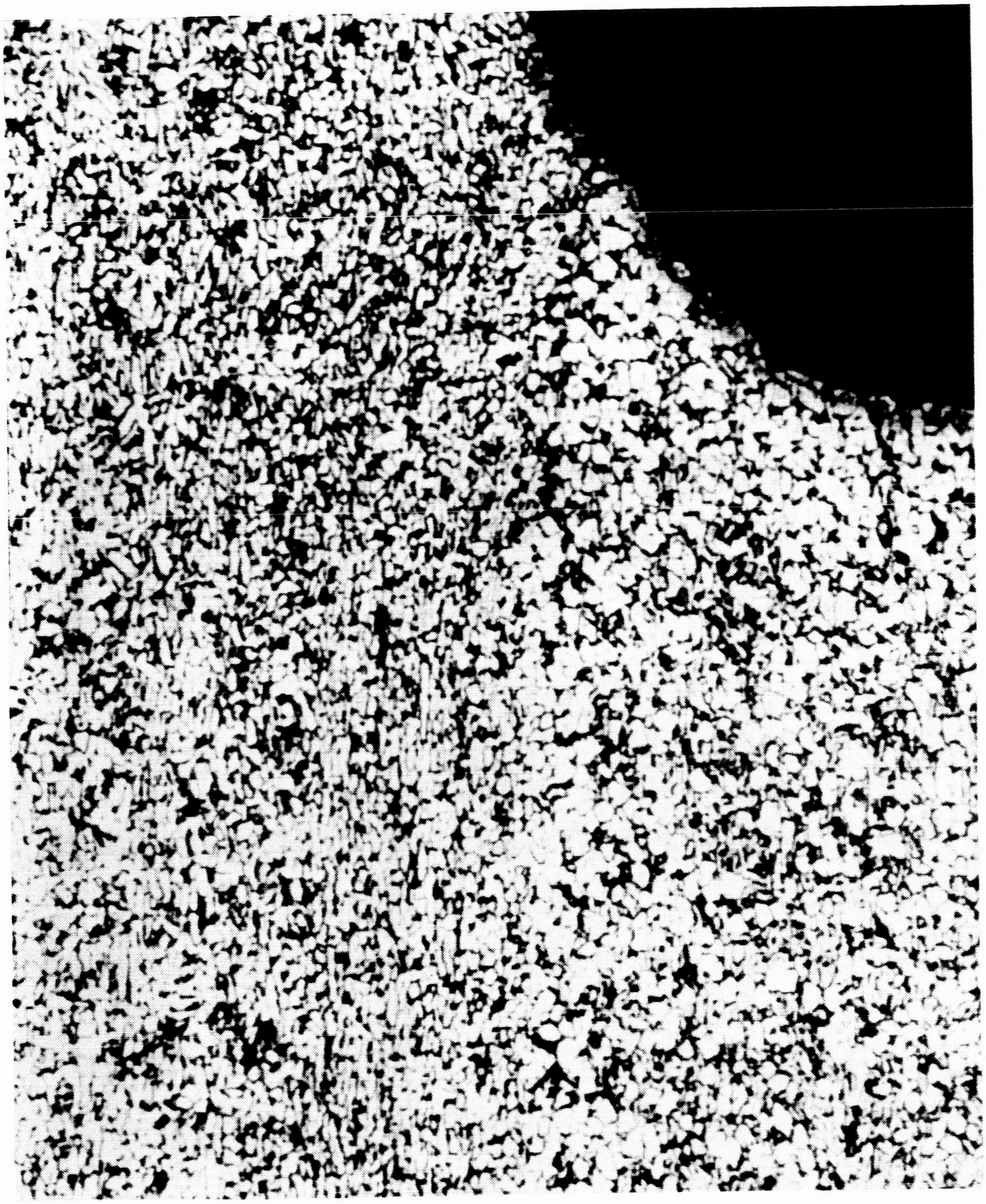


Figure 6. Typical Microphotograph of Bond Area

Both panels will be nondestructively inspected, using ultrasonic and penetrant inspection techniques.

The half-panel which will remain at NAA will be tested and evaluated by PDL to determine tensile strength, bond adhesion, chemistry, bendability, microstructure, and notched-to-unnotched tensile ratio. The latter test is planned to assure that the titanium is in the duplex annealed condition.

These tests will be located at frequent intervals along the full length of the panel section and will be conducted in accordance with the testing procedures established during Phase I.